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HOW DOES TRANSPORTATION SHAPE INTRAMETROPOLITAN GROWTH? AN ANSWER FROM THE REGIONAL EXPRESS RAIL *

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ABSTRACT: This paper analyzes the influence of transportation infrastructure, and in particular of the Regional Express Rail (RER), on employment and population growth in the Paris metropolitan area between 1968 and 2010. In order to make proper causal inference, we rely on historical instruments and control for all other transportation modes that could be complement or substitute to the RER. A dynamic analysis accounting for spatial heterogeneity reveals that for municipalities located less than 13 kilometers from an RER station, each kilometer closer to the station increases employment and population growth by 12% and 8% respectively. Regarding the time pattern of these effects, we find no impact of the RER expansion on employment growth during the first part of the period, while the effect on population growth appears earlier but declines over time.

JEL Codes: R11, R12, R42, L91

Keywords: Urban growth, urban spatial structure, transportation

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1 Introduction

During recent decades the city of Paris and its metropolitan area have undergone major demographic and socioeconomic changes. Specifically, between 1968 and 2010, the Paris Metropolitan Area strengthened its position both as the most populated area (around 12 million inhabitants) and as the largest economic region in the country (with one fifth of the total employment). However, this growth has not been homogeneously distributed throughout the metropolitan area. In fact, even though the levels of employment and population of the whole area grew by 32% and 27%, respectively, during those years, the central business district (CBD) has seen employment fall by 7% and its population by 13%. As a result of these changes, the percentage of employment concentrated in the CBD over the whole area fell from 45% in 1968 to 32% in 2010. The same pattern is repeated for the population of the CBD, which today represents around 19% of the whole area when at the end of the 1960s it stood at 28%. All in all, these trends indicate that the Paris Metropolitan Area has undergone a marked process of suburbanization, accompanied by the emergence of employment subcenters (areas of high employment density outside the CBD).

There is a long tradition in the literature of studies seeking to explain the determinants of city structure and city growth. Typically, in answering the questions as to why some cities are more successful, and grow more rapidly than others or how the urban structure changes, a variety of responses have been reported. Some authors emphasize the importance of human capital and skills (Moretti (2004) and (Rosenthal and Strange, 2008) are good examples); others focus on the role of the weather (Glaeser et al., 2001) or the availability of consumer amenities (Carlino and Saiz, 2008) as attractors for population. Ultimately, however, the literature agrees that a city's density seems to account for its capacity to be productive and to attract better firms and workers (Combes et al., 2012). For urban economists, agglomeration economies are therefore considered an important source of city growth. What is also clear is that the advantages provided by agglomeration economies increase with a reduction in the transportation costs for goods and people (Glaeser and Gottlieb, 2009). Yet even though transportation seems to be a key element for population distribution and growth, until recently its impact on urban growth has not been the focus of much of the existing empirical literature.

In fact, along with the major socioeconomic and demographic changes that have taken place, the Paris Metropolitan Area has seen a great improvement in its transportation networks. The RER (*Réseau Express Régional*) has been increased in length by around 550 km and today operates 257 stations connecting more than 170 municipalities. Likewise, the metro and tramway networks have also been expanded throughout the area. Most notably, the area's main road system (highways) has been extended by 600 km, while the number of ramps and accessibility to many other municipalities have been increased.

The main objective of this paper is to analyze the spatial influence of this transportation infrastructure on the employment and population growth of the municipalities in the Paris Metropolitan Area for the period 1968-2010. Although we focus our attention mainly on the expansion of the

RER and its effects on the location of new jobs and inhabitants, we take considerable efforts to control for all the changes in the area's other transportation modes. Indeed, to obtain unbiased results we need to include in our analysis all the other transportation modes that might complement or substitute the RER system. To do so, we first analyze the changes in Paris' urban spatial structure between 1968 and 2010 through the delimitation of its employment subcenters. We then turn to analyze the spatial influence of transportation infrastructure on the 2010 intrametropolitan distribution of employment and population. We finally estimate whether transportation fostered employment and population growth during this period.

Our study is related to recent empirical studies that have examined other aspects of transportation infrastructure. Sharing our intrametropolitan approach, Baum-Snow (2007, 2010) tests the effect of highway improvements on the suburbanization pattern for the US and on commuting patterns within and between central cities and suburbs, respectively. Garcia-López et al. (2015a) and Garcia-López et al. (2015b) estimate the effects of highways on the suburbanization of Spanish and European cities, respectively. At a county level, Michaels (2008) analyzes the relation between highways and workers' earnings, and Jiwattanakulpaisarn et al. (2009) study the effect of highway infrastructure investment on employment growth. Duranton and Turner (2011) and Hsu and Zhang (2014) provide intermetropolitan evidence for the effect of highway improvements on congestion in the US and Japan, respectively. Duranton and Turner (2012) also find that the stock of highways has a positive impact on urban growth in US metropolitan areas. In the development economic literature there are some recent papers analyzing the effect of infrastructures on different city outcomes. Banerjee et al. (2012) examine the effects of access to transportation networks on economic outcomes in Chinese counties. Faber (2014) studies the impact of the Chinese National Trunk Highway System on city growth. Finally, Donaldson (2015) analyzes the incidence of Indian railroads in the late 19th and early 20th centuries and finds marked effects on trade and welfare.

Two problems of inference need to be accounted for in this type of approach when analyzing the impact of infrastructure improvements on city growth. First, all types of infrastructure take time to be built and their effects on city growth are not immediate. This problem can be solved by using long differences for both employment or population and infrastructure changes. Second, it is reasonable to assume that infrastructures, funded basically out of public budgets, are not assigned at random in a country's geography. Intuitively, if we detect more growth in cities with higher investment in their infrastructure, can we conclude that the new infrastructure is responsible for this growth or that this infrastructure is located in the most successful cities? Or, alternatively, is it that new infrastructure attract more productive firms and workers? This problem of causality is not easily addressed and is one of the main issues raised in defining an empirical approach to the analyses conducted. Only recently have a few papers sought to explain the relation between infrastructure improvement and city growth by considering various inference strategies to address these problems. Baum-Snow (2007) was the first paper to use the U.S. 1947 Highway Interstate Plan as an instrument for the current highway system. Michaels (2008) also makes use of this

1947 plan as an instrument for highway location, together with other variables capturing the geographical location of the county in relation to the nearest major city. Jiwattanakulpaisarn et al. (2009) alternatively uses the lagged levels of highway lane-mile density as instruments for highway infrastructure investments. Finally, another strategy to solve the causality problem has been to use historical instruments. For instance, Duranton and Turner (2011) instrument road infrastructure using the U.S. railway network at the end of the 19th century and the routes taken by major expeditions of the United States between 1518 and 1850, together with the 1947 plan. Hsu and Zhang (2014) use the historical railway network plan of 1890 and the planned national express way extension as exogenous sources of variation of highway location in Japan, while Garcia-López et al. (2015a) use the Roman roads and the 1760 Postal routes as instruments for Spanish highways. Garcia-López et al. (2015b) also instrument European highways and railways with the 1810 postal roads and the 19th century railroads, respectively. Our empirical strategy follows this approach, as we rely on historical instruments: as discussed more extensively later, the 1870 railways and the Roman roads will be the main candidates.

Special mention needs to be made to Mayer and Trévien (2015) who focus on the Paris region to evaluate the impact of the opening and of the progressive extension of the RER between 1975 and 1990 on employment, number of firms, and population at the municipal level. Their identification strategy exploits the deviation from the initial investment plan for the RER network resulting from budgetary and technical constraints. They this natural experiment in a difference-in-difference approach and find that the presence of an RER station increases municipal employment growth, but has no effect on population growth.

In line with this study, our results show that the RER network influences the location of employment and population, even after controlling for other modes of transportation. Getting closer to an RER station is found to increase employment and population density by around 5%. Furthermore, a dynamic analysis reveals that improving the RER network significantly increases municipal employment and population growth: for each kilometer closer to an RER station, employment increases by 2% and population by 1%. Although this impact is limited, it is considerably reinforced once we introduce spatial and temporal heterogeneity in the analysis. For municipalities located less than 13 kilometers from an RER station, each kilometer closer to the station increases employment and population growth by 12% and 8% respectively. Regarding the time pattern of these effects, we find no impact of the RER expansion on employment growth during the first part of the covered period, while the impact on population growth was sizeable much earlier but declined over time.

This paper makes three primary contributions to the literature. First, we analyze the impact of RER improvements on employment and population growth for all the 1,300 municipalities in an area, the Paris metropolitan area, which has witnessed an important improvement in its transportation system in recent decades. Second, to the best of our knowledge, this is the first work to undertake an analysis of the causal effects of improvements to an infrastructure system on city growth controlling for all the possible modes of transportation (railroads, metro, tramways and highways). Third, our empirical strategy allows us to solve the causality problem that is common in this type of approach through the use of historical instruments.

Following on from this introduction, the rest of the paper is organized as follows. In Section 2, we describe the changes in the urban spatial structure in Paris metropolitan area and we explain the suburbanization process of the area through the identification of employment subcenters and their changes with time. In Section 3, we explain the main changes in the different transportation infrastructures in the Paris metropolitan area. We also test whether the past infrastructures are good determinants of the modern infrastructures. In Section 4, we present the main results, and Section 5 concludes.

2 Urban spatial structure in Paris metropolitan area

2.1 Main characteristics

In this first descriptive part of our study, we rely on census data provided by the French statistical institute, the INSEE. Between the early 1960s and the late 1990s, one census surveying all individuals living in France was conducted about every decade. Since 2004, the design and sampling methodology of the census has changed completely, and is now conducted annually over a fraction of the population, so that the census data labeled "year n" is in fact collected over five years ($n-2$ to $n+2$).[1] Apart from this methodological change, all census waves provide us with the same type of information, which can be aggregated at the municipal level. For this paper, we are particularly interested in the number of individuals living and working in each municipality. In addition, the census enables us to characterize the population in terms of demographics (e.g., age, gender, nationality, birth country, marital status, household size) and socio-economics (level of education, socio-economic category of the job, or type of occupation for instance). Our study is based on the 1968-2010 period, during which the main highways were built in Ile de France, and which also corresponds to the period when the railway networks underwent significant improvements (further details on this topic are given in section 3.1). We are therefore using the 1968, 1975, 1982, 1990, 1999 and 2010 waves of the census.

Let us now broadly describe the main spatial features of the Paris metropolitan area which constitutes the focus of this paper. We are actually considering one of the 22 administrative regions in continental France, known as *Ile de France*, which is the region encompassing the city of Paris. It is divided into eight *départements* (administrative subregions) and 1,300 municipalities. Note that the city of Paris has been a *département* of its own since 1968, and is divided into 20 *arrondissements* (that we treat as municipalities). The municipality is the unit of analysis of this paper. It is actually the smallest administrative division that we can use, since smaller divisions were not introduced in French statistics before the 1990s. This is however a reasonable unit of analysis given our research

[1] More details on this new sampling methodology can be found in English on the INSEE webpage.

agenda as French municipalities are particularly small.[2] In *Ile de France*, the average municipal surface is 9.3 km^2, and the median is 7.6 km^2.

The metropolitan area of Paris is the densest and most populated region in France, with 986.7 inhabitants per square kilometer in 2011 for a total of 11,852,851 inhabitants. It is also the main employment center in the country, with a total of 5,660,253 jobs in 2011, corresponding to more than one fifth of total employment in continental France. Among them, 0.2% work in the agricultural sector, 5.2% in the construction sector, 8.4% in industry and the remaining 86.2% in the tertiary sector (trade, services, public administration, education, among others). In the following subsection, we provide a detailed description of the urban spatial structure of Paris metropolitan area.

2.2 CBD, subcenters and other municipalities

With its 20 *arrondissements* expanding over 105.4 km^2 for a density of 21,347 inhabitant per square kilometer, the city of Paris constitutes the CBD of the Paris metropolitan area. In 2011, Paris population amounted to about 2,250,000 inhabitants, corresponding to 19% of the metropolitan population. The CBD also accounted for 32% of the metropolitan employment, with about 1,800,000 jobs, concentrated in the tertiary sector: 67.9% in trade, transportation and services and another 24.4% in public administration, education, health and social services. We can notice from these figures that tertiary sector jobs are over-represented in the CBD: 92.3% of all jobs in Paris compared to 86.2% of all jobs in the metropolitan area of Paris (including the CBD).

As most large agglomerations, the Paris metropolitan area includes several employment subcenters in addition to the CBD, where a subcenter can be defined as an area with significantly higher employment density than that found in nearby locations, and which has a significant effect on the overall employment density function. We identify employment subcenters using the method first developed by McDonald and Prather (1994) and improved by McMillen (2001). The principal idea is to estimate densities following a monocentric spatial pattern. The predicted densities obtained are subtracted from the corresponding real densities. From these residuals, those that are positive are chosen, and from these, those that are statistically significant are selected.

While McDonald and Prather (1994) estimate by OLS a two-dimensional density function, the log of employment density vs. the distance to CBD, McMillen (2001) proposes a three-dimensional density function, the log of employment density versus the north-south and the east-west distances to CBD, and uses a nonparametric estimation technique, known as locally weighted regression (LWR). Both improvements allow us to take into account geographical differences, which, in terms of the spatial pattern of densities, can occur in any direction from the CBD (e.g., steeper density gradients on the north side than on the south side of the city). Furthermore, they also allow us to define any type of monocentric spatial pattern: concave, convex or linear (McMillen, 2001).

As a result, we first estimate the following employment density equation (1) through LWR

[2] Mainland France comprises more than 36,500 municipalities

with a window size or bandwidth of 0.5, i.e., based on a tricube function, the nearest of the 50% observations receive weight (McMillen, 2001):

$$\begin{aligned}\ln(\text{Employment density}) = \alpha_0 + \alpha_2 \times \text{north-south distance to CBD} \\ + \alpha_3 \times \text{east-west distance to CBD}\end{aligned} \tag{1}$$

where density is measured as jobs (respectively, inhabitants) per hectare, and distances are in kilometers. The CBD is defined as the 20 *arrondissements* that make up the city of Paris. Distance to CBD is the distance to the centroid of the *4th arrondissement (de l'Hôtel-de-Ville)*.

Second, for each site i we compute the residual as the difference between real employment density and estimated employment density, and select the ones that are significantly greater than 0 a the 10% level:

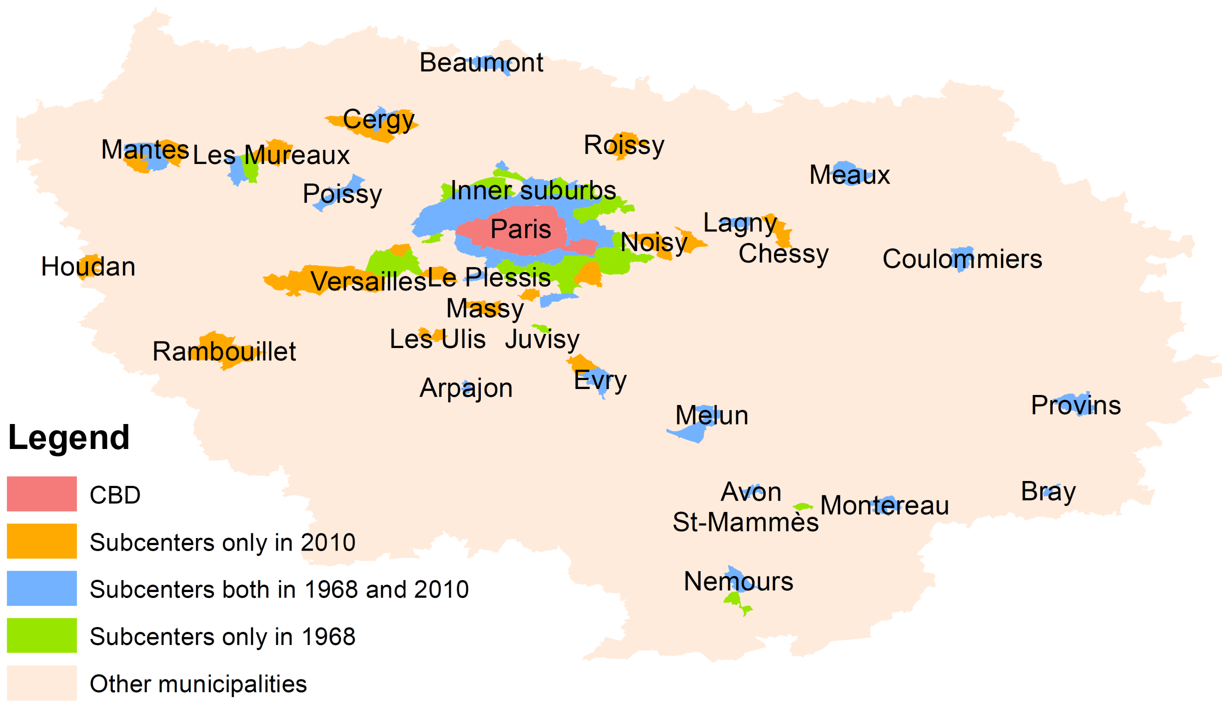
$$\frac{\ln(\text{Employment density}) - \ln(\widehat{\text{Employment}}\ \text{density})}{\widehat{\text{Standard}}\ \text{error}_i} > 1.64 \tag{2}$$

Finally, we group the selected sites in subcenters when they are contiguous. We use a 'queen' criterion for contiguity: two sites (municipalities) are contiguous if they share at least one point in their boundaries. See McMillen (2001, 2003) and Garcia-López (2010) for further details on this procedure.

We apply this methodology to identify subcenters in 1968 and in 2010 in the Paris metropolitan area. This enables us to follow the evolution of the urban spatial structure of this area during the period when the main highway and railway improvements were made, as we show in the next section. In 1968, we identify 21 employment subcenters, comprising 88 municipalities, in addition to the CBD of Paris; in 2010, we identify 34 subcenters comprising 89 municipalities surrounding the CBD. At both dates, about two thirds of the subcenters identified constitute in fact a single municipality: there were six subcenters including several municipalities in 1968 and eleven in 2010. It is however worth noting that the inner suburbs of Paris (the municipalities immediately surrounding the CBD) constituted a macro-subcenter containing 63 municipalities in 1968 and 37 in 2010. Overall, 117 municipalities of the metropolitan area belonged to an employment subcenter at least once in 1968 or 2010. Among these, 28 belonged to a subcenter in 1968 only, 29 in 2010 only, and the remaining 60 were part of a subcenter at both dates. These municipalities are depicted in Figure 1.

Further details are available in Table 1 presenting the main characteristics of all identified subcenters. Column 1 indicates the year for which a given subcenter was identified: 1968, 2010 or both. The types of changes between the two periods are indicated in Column 2: O = Old subcenter that was identified in 1968 but not in 2010; R = Reduced subcenter, that existed in 1968 but only part of it remains in a subcenter in 2010; E = Extended subcenter, that existed in 1968 and includes new muncipalities in 2010; I = Identical subcenter, that was identified at both dates and similar; S(X) = Separated subcenter, that belonged to subcenter X in 1968 and in an independent subcenter in 2010; N = New subcenter, that did not exist in 1968 and was identified in 2010 (N(X) indicates that the new subcenter "replaces" old subcenter X). Columns 3 and 4 indicate the number of municipalities in each subcenter in 1968 and 2010 respectively. Columns 5 and 6 report the total population living in the subcenters in 1968 and 2010 respectively, and the corresponding growth rate is in Column 7 when available. The number of jobs in the subcenters in 1968 and 2010 are displayed in Columns 8 and 9, and the corresponding growth rate is in Column 10 when available. Finally, Column 11 shows the average distance (in kilometers) between the center of the subcenter and the CBD, computed using a GIS software.

Figure 1: Employment subcenters in Paris metropolitan area, 1968 and 2010



Note that a couple of papers have previously performed a similar exercise of subcenter identification in the Paris region for different points in time. Gilli (2009) used a similar methodology to the one described above for the year 1999 in a paper aimed at characterizing the dynamics of the decentralization process in *Greater Paris*, but with no specific focus on transportation. The subcenters he identifies for that year are reassuringly consistent with ours. In another descriptive paper, Guillain et al. (2006) also identified employment centers in Ile-de-France in 1978 and 1997, by performing an exploratory spatial data analysis on the employment-to-population ratio. The subcenters they identify correspond however mostly to the five government-planned towns (*villes nouvelles*). By contrast, in the closest paper to ours, focusing on the role of public transportation in Ile-de-France, Mayer and Trévien (2015) do not identify subcenters in this region. Instead, they base their analysis on municipalities classified according to their distance from the CBD.

Table 1: Emplovment subcenters in metropolita Paris, 1968–2010

Label	Year identified	Evolution	Nb municipalities 1968	2010	Population 1968	2010	Population growth (%)	Employment 1968	2010	Employment growth (%)	Average dist CBD (km)
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Inner Suburbs (1)	1968, 2010	R	63	37	2,711,100	1,903,650	-29.78	1,201,872	1,163,615	-3.18	4.5
Enghien-les-bains	2010	S (1)		1		11,809			5,161		7.6
Le Bourget	2010	S (1)		1		14,864			7,374		6.6
Créteil	2010	S (1)		1		89,985			52,972		7.7
Orly	2010	S (1)		2		27,057			55,200		7.8
Le Plessis-Robinson	1968, 2010	I	1	1	22,557	27,727	22.92	8,996	14,304	59.01	6.6
Versailles (2)	1968	O	1		90,829			40,696			10.7
Vélizy-Villacoublay	2010	N (2)		1		20,089			39,160		8.3
Le Chesnay	2010	N (2)		1		28,975			12,629		9.6
Guyancourt	2010	N (2)		6		142,184			94,638		13.3
Poissy	1968, 2010	I	1	1	33,613	37,680	12.10	24,044	23,741	-1.26	14.6
Aubergenville - Flins (3)	1968, 2010	R	2	1	8,936	12,020	34.51	11,516	6,127	-46.80	22.7
Meulan-Les Mureaux	2010	N (3)		2		39,714			15,790		21
Cergy - Pontoise	1968, 2010	E	1	4	16,827	127,030	654.92	9,060	72,086	695.65	17
Beaumont	1968, 2010	I	2	2	13,902	19,452	39.92	5,832	6,886	18.08	20.1
Lagny-sur-Marne	1968, 2010	I	1	1	15,743	20,236	28.54	6,088	10,402	70.86	17
Meaux	1968, 2010	I	1	1	30,214	50,755	67.99	12,792	22,583	76.54	26.5
Coulommiers	1968, 2010	I	1	1	11,263	14,544	29.13	5,088	7,889	55.05	34.6
Provins	1968, 2010	I	1	1	11,432	12,301	7.60	5,312	7,352	38.41	48.1
Bray-sur-Seine	1968, 2010	I	1	1	1,913	2,397	25.30	1,068	1,365	27.83	51.7
Montereau-Fault-Yonne	1968, 2010	I	1	1	19,789	16,681	-15.71	8,768	9,044	3.14	43.4
Saint-Mammès	1968	O	1		2,694			880			39.6
Nemours	1968, 2010	R	2	1	10,189	12,745	25.09	6,624	6,695	1.07	46.1
Avon	1968, 2010	I	1	1	13,552	13,984	3.19	3,012	3,959	31.43	35.9
Melun	1968, 2010	I	2	2	46,581	60,311	29.48	23,128	32,548	40.73	26.4
Evry	1968, 2010	E	1	2	32,192	95,221	195.79	19,104	56,993	198.33	17.8
Juvisy-sur-Orge	1968	O	1		12,628			5,120			11.9
Arpajon	1968, 2010	I	1	1	6,576	10,574	60.80	3,672	5,518	50.27	19.2
Mantes-la-Jolie	1968, 2010	E	2	5	40,694	86,697	113.05	16,400	30,203	84.16	30.6
Massy	2010	N		1		42,258			26,141		9.7
Les Ulis	2010	N		1		24,792			19,611		14.2
Rambouillet	2010	N		1		26,159			13,035		27.3
Houdant	2010	N		1		3,289			2,643		33.9
Roissy-en-France	2010	N		1		2,750			90,013		12.9
Noisy-le-Grand	2010	N		1		62,964			28,358		10.6
Lognes	2010	N		2		30,220			17,342		13.7
Chessy	2010	N		2		11,893			17,344		19.8

O = Old; R = Reduced; E = Extended; I = Identical; S(X) = Separated from X; N = New subcenter. See text for more details.

2.3 *Employment and population suburbanization*

After identifying the main characteristics of the urban spatial structure in Paris metropolitan area, we now study its temporal and spatial trends. First, we explore the absolute and relative importance of three groups of municipalities: the CBD, the subcenters, and the other municipalities. Second, we analyze the spatial influence of the CBD and the subcenters on the location decisions of firms and residences.

Table 2: Employment and population in metropolitan Paris, 1968–2010

Panel A: Employment	1968 Subcenters			2010 Subcenters		
	1968	2010	1968–2010	1968	2010	1968–2010
Paris	1,935,716 (45.26%)	1,797,678 (31.71%)	-138,038 (-7.1%)	1,935,716 (45.26%)	1,797,678 (31.71%)	-138,038 (-7.1%)
Subcenters	1,419,072 (33.18%)	1,762,894 (31.10%)	343,822 (24.2%)	1,132,124 (26.47%)	1,978,722 (34.91%)	846,598 (74.8%)
Non-central municipalities	921,992 (21.56%)	2,108,330 (37.19%)	1,186,338 (129%)	1,208,940 (28.27%)	1,892,502 (33.38%)	683,562 (56.5%)
Total	4,276,780	5,668,902	1,392,122 (32.6%)	4,276,780	5,668,902	1,392,122 (32.6%)
Panel B: Population	1968 Subcenters			2010 Subcenters		
	1968	2010	1968–2010	1968	2010	1968–2010
Paris	2,590,771 (28.01%)	2,243,833 (19.04%)	-346,938 (-13.4%)	2,590,771 (28.01%)	2,243,833 (19.04%)	-346,938 (-13.4%)
Subcenters	3,153,224 (34.10%)	3,472,991 (29.46%)	319,767 (10.1%)	2,370,046 (25.63%)	3,103,007 (26.33%)	732,961 (30.9%)
Non-central municipalities	3,504,637 (37.89%)	6,069,410 (51.50%)	2,564,773 (73.2%)	4,287,815 (46.36%)	6,439,394 (54.63%)	2,151,579 (50.2%)
Total	9,248,632	11,786,234	2,537,602 (27.4%)	9,248,632	11,786,234	2,537,602 (27.4%)

Note: Metropolitan shares and growth rates in parentheses.

Table 2 reports the number of jobs (Panel A) and inhabitants (Panel B) in the CBD, subcenters and other municipalities in 1968 and 2010, based either on the subcenters identified in 1968 (first three columns) or, alternatively, on those identified in 2010 (last three columns). The total numbers in the bottom line of each panel reveal that the Paris Metropolitan Area as a whole grew by about one third over the period, both in terms of employment (32.6%) and population (27.4%). Disaggregating these figures between CBD, subcenters and other locations enables us to detect the suburbanization process that the Paris metropolitan area has been experiencing since 1968. Indeed, we see that the number of jobs in the CBD decreased by 7.1%, while the population size fell by 13.4%, to the benefit of subcenters and other municipalities. This evolution reflects an absolute suburbanization process. We can also see that the CBD's share of total employment and population dropped respectively from 45.3% to 31.7% and from 28% to 19%. Taking a closer look at the subcenters and comparing the 1968 situation of the subcenters identified in 1968 with the 2010 situation of those identified in 2010, we can observe that they gained in terms of employment, both in absolute and relative terms (from 33% to 35%), illustrating a process of absolute and relative employment centralization in the subcenters. On the other hand, subcenters lost in terms of population, both in absolute and relative terms (from 34% to 26%), to the benefit of other municipalities: the subcenters have themselves been undergoing a population suburbanization process towards the smaller municipalities.

To analyze the influence of the CBD and the subcenters on the intrametropolitan distribution of employment and population, we regress the log of the 2010 employment (alternatively, population) density on the distance to CBD, the distance to the nearest employment subcenter (where we alternatively use subcenters identified in 1968 and 2010), and a vector of geographic characteristics, which includes land area, altitude, ruggedness index and elevation range:

$$\begin{aligned} \ln(\text{Density}) = \beta_0 &+ \beta_1 \times \text{distance to CBD} \\ &+ \beta_2 \times \text{distance to the nearest subcenter} \\ &+ \sum_i (\beta_{3,i} \times \text{geography}_i) \end{aligned} \tag{3}$$

where the coefficients β_1 and β_2 are the so-called density gradients and capture the extent to which density falls with distance to CBD and distance to the nearest subcenter, respectively.

Table 3: Urban spatial structure and proximity to employment centers, OLS

	2010 ln(Density)					1968–2010 Δln(Density)			
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Panel A: Employment									
Distance to CBD	-0.088^a	-0.082^a	-0.075^a	-0.074^a	-0.068^a	-0.019^a	-0.016^a	-0.031^a	-0.027^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Dist. nearest 1968 subcenter		-0.075^a		-0.049^a		-0.025^a		-0.030^a	
		(0.006)		(0.006)		(0.004)		(0.004)	
Dist. nearest 2010 subcenter			-0.101^a		-0.076^a		-0.041^a		-0.049^a
			(0.009)		(0.008)		(0.006)		(0.006)
1968 $\ln(D)$								-0.211^a	-0.221^a
								(0.027)	(0.027)
Geography	N	N	N	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.59	0.63	0.64	0.67	0.68	0.15	0.17	0.23	0.26
Panel B: Population									
Distance to CBD	-0.072^a	-0.067^a	-0.062^a	-0.057^a	-0.053^a	-0.004^a	-0.003^a	-0.017^a	-0.016^a
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)
Dist. nearest 1968 subcenter		-0.064^a		-0.034^a		-0.007^b		-0.014^a	
		(0.005)		(0.005)		(0.003)		(0.003)	
Dist. nearest 2010 subcenter			-0.079^a		-0.052^a		-0.012^a		-0.022^a
			(0.006)		(0.006)		(0.004)		(0.005)
1968 $\ln(D)$								-0.249^a	-0.256^a
								(0.031)	(0.032)
Geography	N	N	N	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.60	0.65	0.65	0.70	0.71	0.06	0.06	0.26	0.28

Notes: 1300 observations for each regression. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. Robust standard errors are in parentheses. ^{a}, ^{b}, and ^{c} indicates significant at 1, 5, and 10 percent level, respectively.

Table 3 reports OLS results for Eq. (3). We find that all employment (Panel A) and population

(Panel B) density gradients are negative and significant: the closer a municipality is to the CBD or to a subcenter, the higher its density (this trend is particularly marked for population density). This reveals that both CBD and subcenters influence the spatial pattern of employment and population location in Paris metropolitan area. We can also notice that the density gradients for 2010 subcenters are larger (in absolute values) than those for 1968 subcenters, illustrating the fact that subcenters identified in 2010 are more dynamic by construction (some of them emerged during the period, while some of the 1968 subcenters disappeared as shown in Table 1).

Columns 6 and 7 display the results of similar regressions but where the dependent variable is the density growth (Δln(Density)) between 1968 and 2010. From these results, we can infer that the influence of both CBD and subcenters on the location of jobs and residences increased despite the suburbanization process. Indeed, these negative and significant coefficients mean that the growth of employment and population (densities) was larger for municipalities closer to the CBD and subcenters. Finally, in Columns 8 and 9, we also include the initial densities (in 1968) in the growth equations, in order to account for convergence processes (mean reversion processes). In this case, we can observe that the spatial influence of CBD and subcenters is even higher.

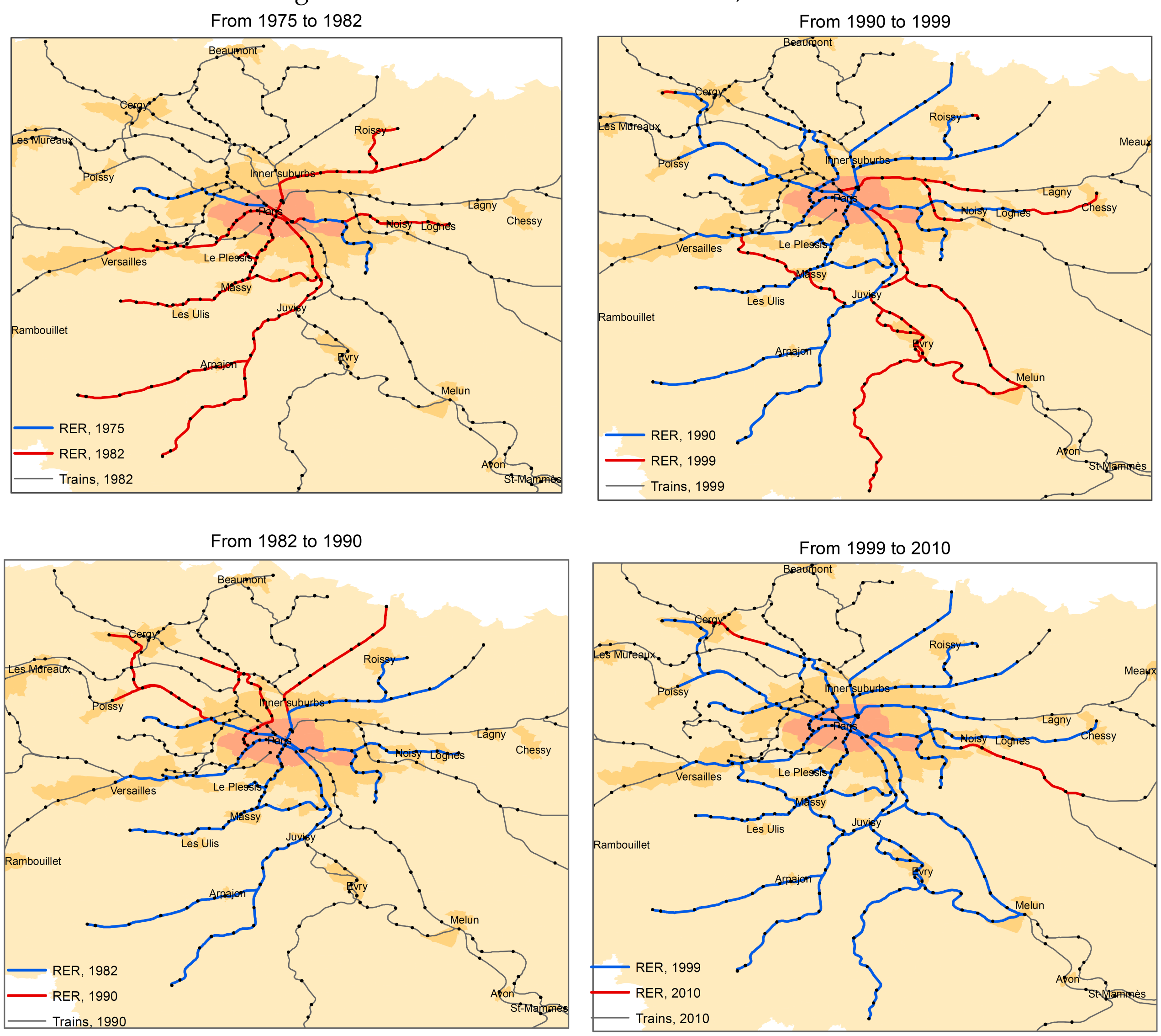
3 Transportation in Paris metropolitan area

3.1 Main characteristics

The transportation infrastructure of the Paris metropolitan area today is based on both a railroad network and a main road system. In the case of the former, there are four network types: First, a suburban train (henceforth train) that connects Paris to the suburbs, including some of the most remote parts of the region. This network was initiated during the first half of the nineteenth century, and has been continuously expanded since then. An important modernization wave took place in the 1960s, with all steam trains being replaced by electric trains. Table 4 Panel A shows the most recent evolution of the train network. The network, which is based on five lines with a total length of 788 km and with 231 stations located in 196 municipalities in 2010, has undergone a slight reduction in the last 40 years.

Second, the Paris region is endowed with a regional express network (*Réseau Express Régional* in French, RER henceforth) which started operating during the second half of the 1970s. Figure 2 shows the evolution of the RER network between 1975 and 2010. Like the train, the RER connects Paris to the suburbs, but for a shorter total distance of about 30 km. Most of the RER lines follow the train lines and were designed to improve the former network. An important distinction between the train and RER networks is that the latter has connections within Paris. This means the RER enables passengers to commute from one part of the Paris Metropolitan Area to another, going through Paris, but without having to switch to another train to cross e city. This represents a clear improvement to regional transit overall. As a whole, the RER network increased its number of lines from 1 to 5, its total length from 39 to 587 km, its number of stations from 22 to 243, and its number of municipalities with stations from 16 to 167 between 1975 and 2010 (Table 4 Panel B). Mayer and Trévien (2015) provide a more detailed history of the rail network in the Paris metropolitan area, and explain thoroughly the differences between the two regional train networks.

Figure 2: Evolution of the RER network, 1975–2010



In addition to these regional railroad networks, Paris is endowed with a very dense subway system (*métro* henceforth), which was opened in 1900 and mainly connects areas within Paris. Between 1968 and 2010, the *métro* network was further expanded with the addition of two new lines that increased its length by 44 km, and 34 new stations were added connecting 13 new municipalities (Table 4 Panel C). Today, a few *métro* stations extend beyond Paris, but they remain within a very limited range.

Finally, Paris metropolitan area also enjoys a tramway network, which is much more recent: the first segments started operating in the beginning of the 1990s, and the network is still expanding.

This network is mostly located at the fringe of Paris, with some segments running in the first ring of municipalities around Paris. Note that while the main regional trains have a radial structure, linking Paris to the suburbs, the tramway is much more circular, the various lines forming a circle around the CBD and along its borders. In 2010, this network was based on 4 lines with a total length of 40 km, with 70 stations connecting 19 municipalities (Table 4 Panel D).

Table 4: The evolution of transportation infrastructures in metropolitan Paris, 1968–2010

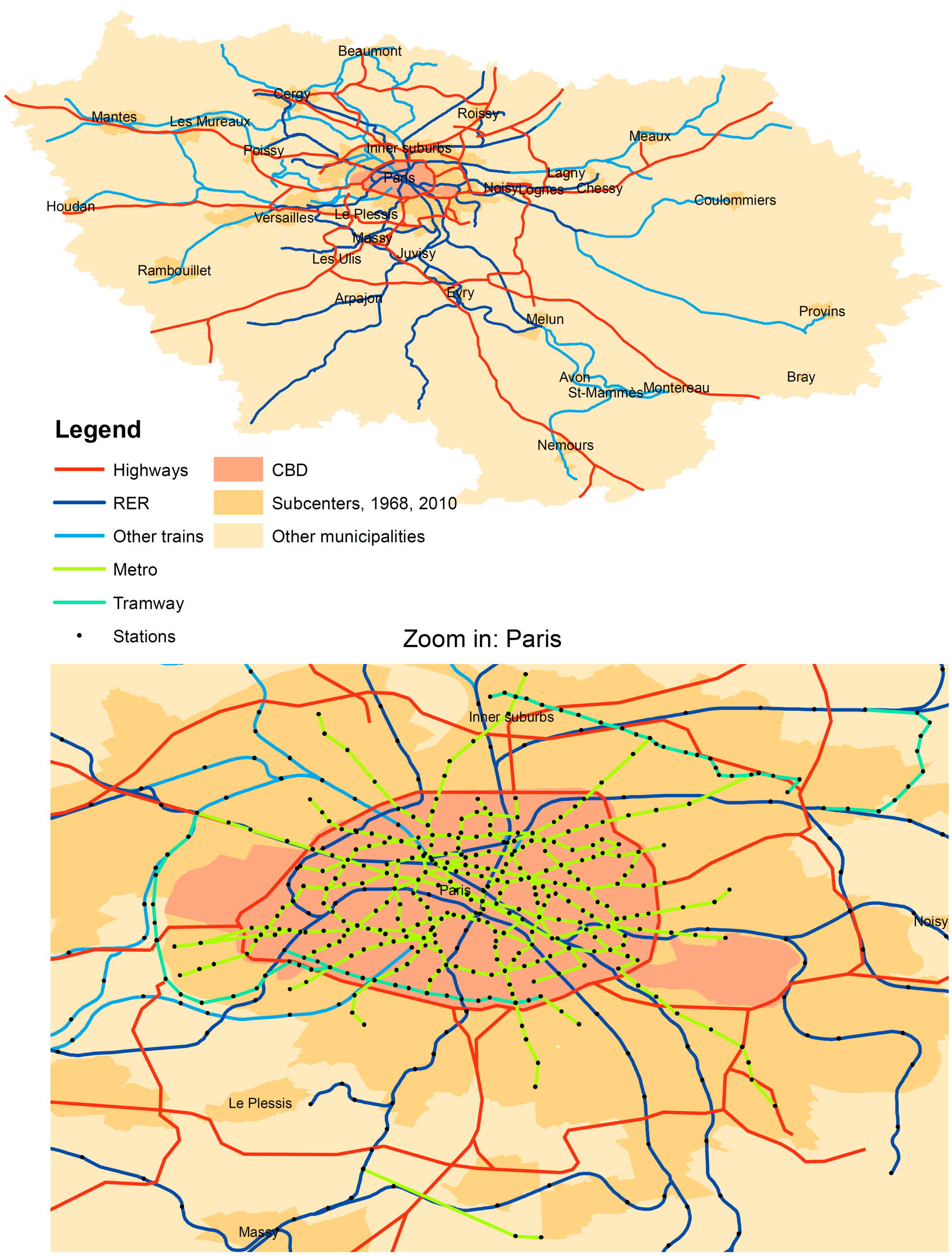
	Year [1]	Stations/Ramps [2]	Stations x Lines [3]	Lines [4]	Municipalities [5]	Length (km) [6]
Panel A: Train	1968	277	281	5	234	870
	1975	274	278	5	233	860
	1982	272	276	5	232	873
	1990	265	269	5	225	584
	1999	231	240	5	198	779
	2010	231	239	5	196	788
Panel B: RER	1968	0	0	0	0	0
	1975	22	22	1	16	39
	1982	126	129	4	84	266
	1990	159	165	4	107	358
	1999	231	240	5	158	562
	2010	243	252	5	167	587
Panel C: Métro	1968	265	338	15	33	164
	1975	273	348	15	36	173
	1982	285	360	15	41	188
	1990	291	366	15	44	196
	1999	296	376	17	46	204
	2010	299	380	17	46	208
Panel D: Tramway	1968	0	0	0	0	0
	1975	0	0	0	0	0
	1982	0	0	0	0	0
	1990	0	0	0	0	0
	1999	34	34	2	9	20
	2010	70	71	4	19	40
Panel E: Highway	1968	46		11	40	229
	1975	86		24	73	418
	1982	111		27	91	549
	1990	129		31	101	633
	1999	161		40	127	792
	2010	168		41	133	821

Notes: For railway infrastructures (Panels A to D), Column 2 reports the total number of stations in which the corresponding type of train stops, Column 3 reports the number of stations weighted by the number of lines (if two lines go through the same station then the station is counted twice), Column 4 reports the total number of lines composing the corresponding network, Column 5 reports the number of municipalities in which there is at least one station of the corresponding network, and Column 6 reports the length of the corresponding railway network (note that if the same railway is used for several lines, its length is counted only once). Information for highways, or more precisely for the main roads (including some roads smaller than highways) is reported in Panel E as follows. Column 2: number of ramps to access the highway. Column 4: total number of roads with a different label composing the highway network. Column 5: number of municipalities in which there is at least one ramp. Column 6: total length of the highway network.

In the case of the main road system, we focus on the highway network (and include some other main roads). Although France's first highway projects date from the 1920s and the 1930s, the real expansion of the French network took place during the second half of the 20th century. In the Paris Metropolitan Area (Table 4 Panel E), the number of highways increased from 11 to 41 between 1968 and 2010, expanding the network from 229 km with 46 ramps in 40 municipalities to 821 km with

168 ramps in 133 municipalities. Figure 3 depicts all railroad networks and the main highways of the Paris metropolitan area in 2010.

Figure 3: Railroad network and main highways in 2010



3.2 *When past infrastructures shape modern infrastructures*

One of the main purposes of this paper is to evaluate whether and to what extent the above mentioned transportation improvements have fostered local growth in Paris metropolitan area, both in terms of jobs and inhabitants. However, first we need to deal with an identification issue because transportation and its improvements are not placed randomly. On the contrary, they are endogenous to employment and/or population growth. Planners may for instance decide to improve the connection of deprived areas in order to boost their economic activity or attract population. In order to address this issue, we adopt an instrumental variable approach in which some variables, named instruments, are used as sources of exogenous variation for our transportation endogenous variables.

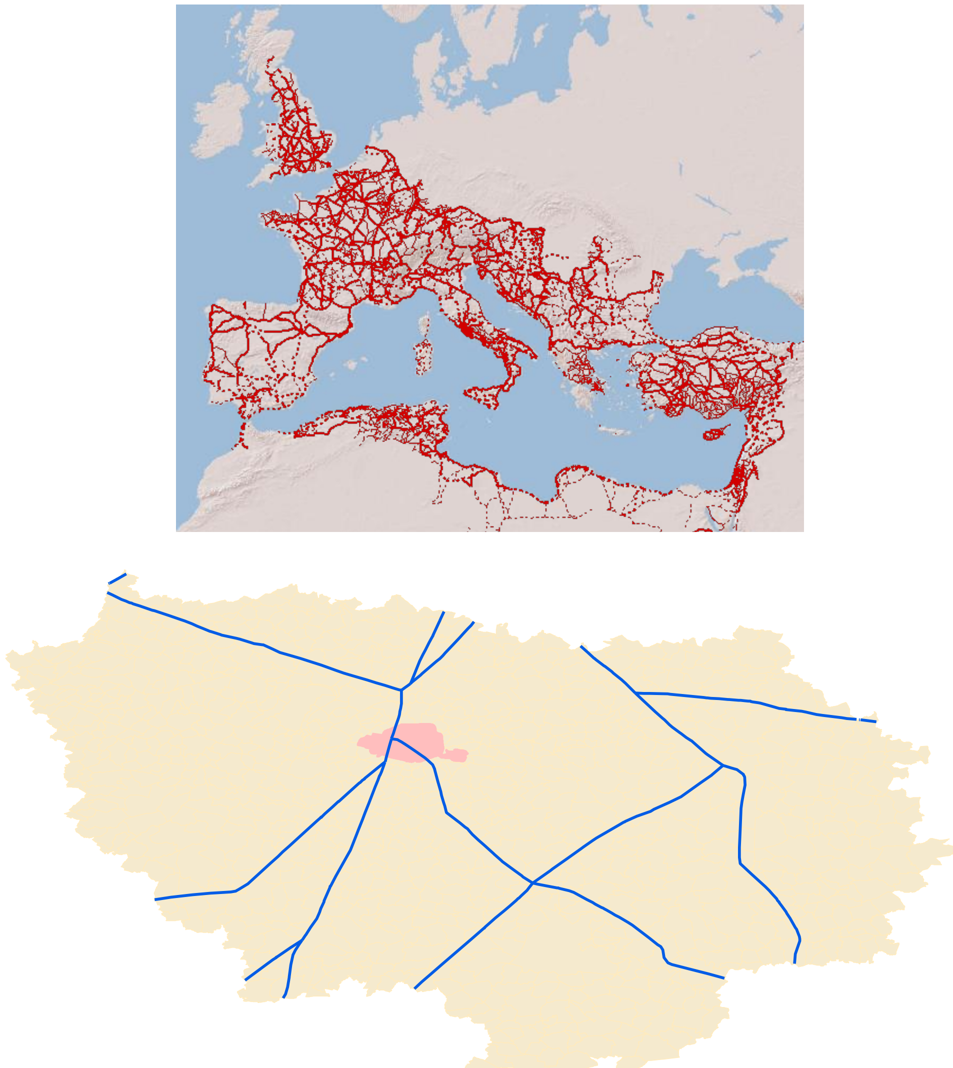
Recent literature highlights the advantages in terms of exogeneity and relevance of using 'historical' and 'planned' instruments. For instance, Baum-Snow (2007), Michaels (2008) and Duranton and Turner (2012) use the 1947 plan of the interstate highway system as an instrument for modern highways in the US, and Duranton and Turner (2012) additionally rely on the 1898 railroad network. Garcia-López (2012) uses the ancient Roman roads, and the 19th century main road and railroad networks as instruments for highways and railroads in metropolitan Barcelona. Finally, Garcia-López et al. (2015a) use the ancient Roman roads and the 1760 Bourbon roads (post routes) to instrument current highways in Spain.

Following the above mentioned literature, we consider three candidates to instrument highways and railroads in Paris metropolitan area: the Roman roads, the 1810 post routes, and the 1870 railroads. In the following paragraphs, we explore their validity in termes of exogeneity and relevance.

The Roman roads

The first Roman road on French territory (Gaul) was built in 118 B.C.: the *Via Domitia* connected Italy to Spain along the south coast of France. The two main Roman roads passing through Paris (Lutetia at the time) were built a few years later. The *Chaussée Jules César* (Julius Caesar road) linked Paris to Rouen, a city located 125 kilometers north-west of Paris. The road possessed relays every 15 kilometers, thereby enabling mail to travel between Paris and Rouen within a day. The *Chaussée de la Reine Blanche* (White Queen road) linked Paris to Beauvais, a city located 80 kilometers north of Paris. Including also several secondary roads, the Roman network in Paris metropolitan area was based on 526 km of roads (Figure 4).

Figure 4: The Roman roads

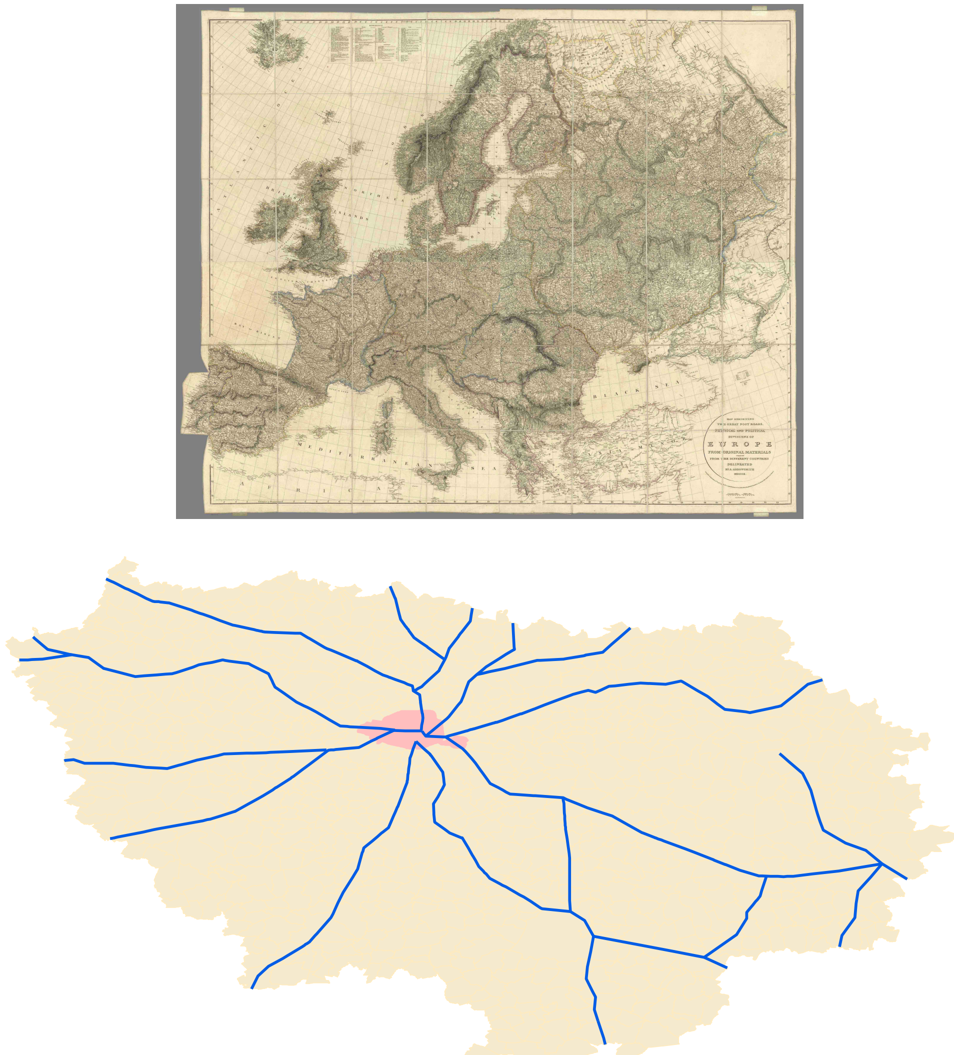


Source: Own elaboration based on the Digital Atlas of Roman and Medieval Civilizations.

The 1810 post routes

Our second proposed instrument is the 1810 post routes. The first fixed relay posts were established in France at the beginning of the 16th century. These relays constituted a set of nodes that were initially intended for the royal postmen to transmit messages and information to and from the king. The postmen rode horses that could be replaced with fresh animals at these relay posts. From the beginning of the 17th century onwards, they progressively came to be used for civilian postal services as well. Over the 18th century, engineers of roads and bridges (*ponts et chaussées*) built roads made of stone that connected the various relay posts. In this way, the itinerary between two relays became more and more fixed by the route taken by these paved roads. Figure 5 shows this 1810 network of paved roads linking the various relay posts around Paris. Because the primary purpose of this network was royal communication, it was star-shaped over all the territory, with Paris at the center, and much denser in the region around Paris than in the rest of France. As a whole, this network was based on 768 km of post roads crossing the modern Paris metropolitan area.

Figure 5: The 1810 post routes

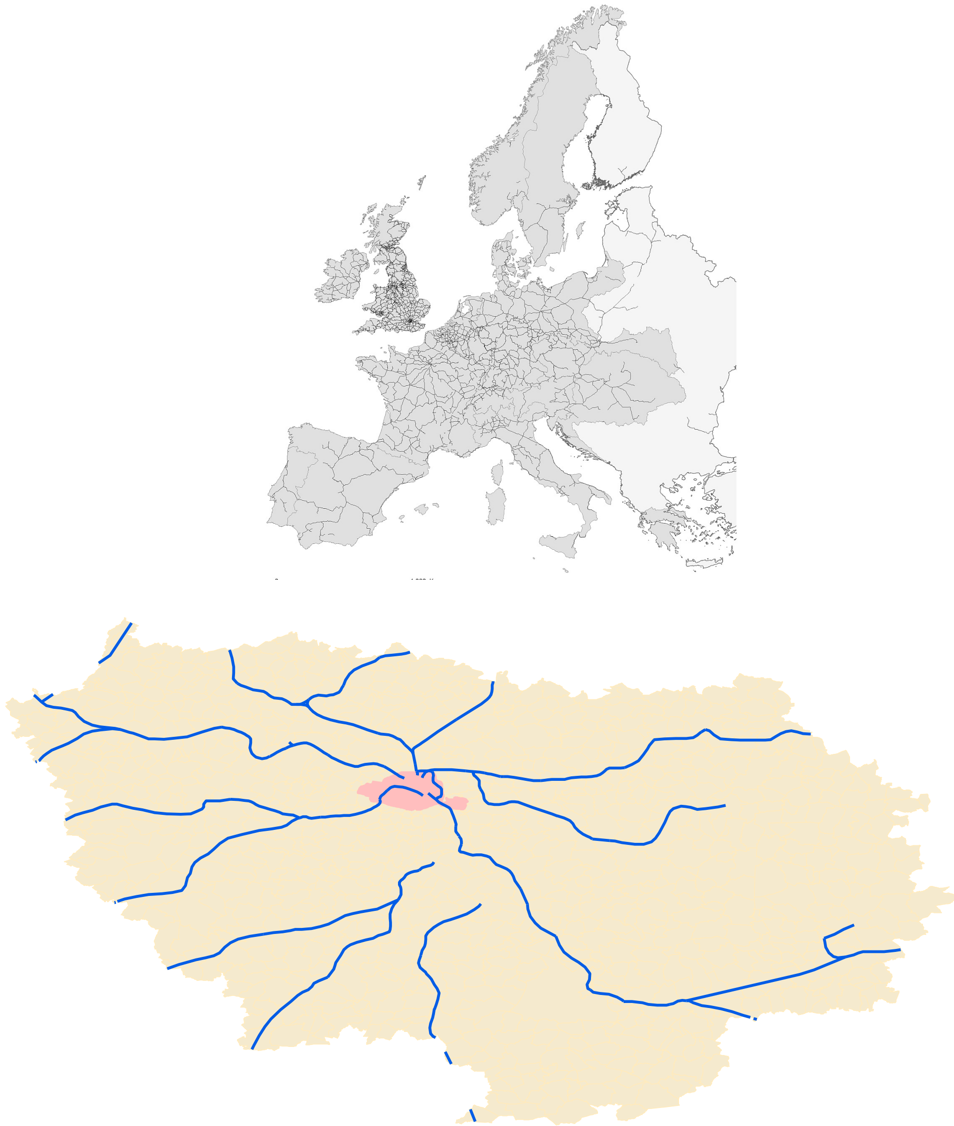


Source: Own elaboration based on digital images of an 1810 Aaron Arrowsmith map from the David Rumsey Historical Map Collection.

The 1870 railroad network

The third candidate is simply the railroad network as it existed in 1870 in the region around Paris. The first French railroads were built at the beginning of the 19th century, but slightly later than in the UK due to the Napoleonic wars: the first line connecting Paris to a city located 18 km away (Saint-Germain) was not opened until 1837. Due to the high levels of centralization in France, the 1870 railroad network (Figure 6) also had a star-shaped form centered around Paris and was based on 698 km of railroad lines.

Figure 6: The 1870 railroads



Source: Own elaboration based on Martí-Henneberg (2013) maps.

Are they valid instruments?

As discussed above, the fact that modern roads and railroads were built following the routes marked out by the ancient infrastructure has been frequently pointed out in the literature. Common sense would suggest that in France as well, the past infrastructure shaped the current provision for the same practical reasons; namely, it was easier and cheaper when building new transportation infrastructure to improve the old infrastructure for instance, or to build it close by (Duranton and Turner, 2012). We now empirically test the credibility of this assumption in the context of the Paris metropolitan area. To do so, we conditionally regress the distance to the nearest transportation infrastructure in 2010 on the distance to the nearest historical transportation infrastructure, while controlling for the urban spatial structure (with the distance to the nearest 2010 employment center[3]), geography and history:

$$\begin{aligned}\text{Distance to 2010 transportation} = \gamma_0 &+ \gamma_1 \times \text{distance to historical transportation}\\ &+ \gamma_2 \times \text{distance to the nearest 2010 employment center}\\ &+ \sum_i (\gamma_{3,i} \times \text{geography}_i) + \sum_i (\gamma_{4,i} \times \text{history}_i)\end{aligned} \tag{4}$$

The inclusion of these control variables is key to our identification strategy. Although ancient transportation infrastructure may be exogenous both because of the length of time that has passed since it was built and of the significant changes undergone by society and the economy in the intervening years, and, more especially, as this infrastructure was not built to anticipate employment and population growth in a distant future, other factors such as the area's geography are likely to have influenced the construction and location of both ancient and modern transportation infrastructures on the grounds of the feasibility and convenience of construction. From this point of view, it is crucial to include geographical characteristics such as land area, altitude, index of terrain ruggedness, and elevation range as controls to comply with the exogeneity condition.

On the other hand, it is equally important to control for the historical context, since this may explain both the presence of former infrastructure and the economic importance of today's municipalities. In order to fulfill the exclusion restriction, and because there are no historical employment and population data at the municipal level prior to 1962 and 1968, we control for history by including dummy variables indicating (1) whether municipalities were Roman settlements, (2) whether they used to be major towns between the 10th and the 15th centuries and (3) between the 16th and the 19th centuries, (4) whether they had a monastery built between the 12th and 16th centuries, and (5) whether they hosted important fairs between the 10th and the 16th centuries. These variables come from the Digital Atlas of Roman and Medieval Civilizations, with the exception of the major cities of the 16th to 19th centuries which are identified in Bairoch (1988). To put it differently, we assume *conditional* exogeneity of the proposed instruments, as suggested by (Duranton and Turner, 2012).

Regarding the relevance of our potential instruments, Table 5 shows (the 'first-stage') results for Eq. (4). Columns 1 to 4 in Panel A display the results for the RER. We can see that the distance to the nearest RER station in 2010 is very highly correlated with the distance to the nearest railroad in 1870 (Column 1) and with the distance to the nearest Roman road (Column 3). The values of their first-stage F-statistics confirm their strength as instruments (Stock and Yogo, 2005). Furthermore, results for the first-stage F-statistic and the overidentification p-value in Column 4 confirm that both instruments can be used simultaneously.

Regarding commuter train, Panel A Columns 5 to 7 show that all three historical networks in-

[3]We use this variable instead of separate distances for CBD and subcenters because the latter are highly correlated with the different transportation distances. In particular, partial correlations between distance to the nearest RER station and distance to CBD and to the nearest 2010 employment subcenters are 85% and 81%, respectively.

dividually matter for the location of train stations. However, there is an overidentification problem when we use them simultaneously (Column 8). In Columns 9 to 11, we use all possible pairs of these three instruments. We find that only the 1870 railroad and Roman road combination (Column 10) passes the overidentification test.

Table 5: Modern transportation as a function of past transportation, OLS

Dependent variable:	2010 Distance to the nearest										
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Panel A: RER and commuter train											
	RER station				commuter train station						
Distance to 1870 railroads	0.961^a			0.853^a	0.187^a			0.168^a	0.182^a	0.177^a	
	(0.079)			(0.073)	(0.039)			(0.036)	(0.038)	(0.038)	
Distance to 1810 roads		-0.101				0.136^a		0.169^a	0.127^a		0.178^a
		(0.105)				(0.041)		(0.043)	(0.042)		(0.042)
Distance to Roman roads			0.616^a	0.574^a			-0.114^a	-0.124^a		-0.110^a	-0.129^a
			(0.036)	(0.036)			(0.013)	(0.013)		(0.013)	(0.013)
Adjusted R^2	0.24	0.17	0.28	0.34	0.40	0.39	0.41	0.44	0.41	0.42	0.42
First-stage statistic	147.06	0.92	300.01	231.26	23.11	10.90	74.11	48.14	16.29	54.98	50.39
Overidentification p-value				0.58				0.00	0.00	0.27	0.01
Panel B: all non-RER railroads → commuter train, subway and tramway											
					non-RER station						
Distance to 1870 railroads					0.171^a			0.152^a	0.165^a	0.161^a	
					(0.038)			(0.036)	(0.037)	(0.037)	
Distance to 1810 roads						0.141^a		0.172^a	0.133^a		0.181^a
						(0.041)		(0.043)	(0.041)		(0.042)
Distance to Roman roads							-0.108^a	-0.119^a		-0.104^a	-0.123^a
							(0.013)	(0.013)		(0.013)	(0.013)
Adjusted R^2					0.42	0.42	0.43	0.45	0.43	0.44	0.44
First-stage statistic					19.75	11.77	66.92	44.06	15.08	48.98	47.00
Overidentification p-value								0.00	0.00	0.29	0.02
Panel C: Highways and combination with non-RER railroads											
	highway ramp				non-RER station or highway ramp						
Distance to 1870 railroads	0.115^b			0.100^b	0.149^a			0.125^a	0.141^a	0.137^a	
	(0.048)			(0.046)	(0.038)			(0.036)	(0.037)	(0.037)	
Distance to 1810 roads		-0.054				0.076^b		0.185^a	0.146^a		0.193^a
		(0.042)				(0.032)		(0.041)	(0.040)		(0.041)
Distance to Roman roads			-0.162^a	-0.159^a			-0.081^a	-0.130^a		-0.115^a	-0.134^a
			(0.018)	(0.018)			(0.011)	(0.012)		(0.013)	(0.013)
Adjusted R^2	0.54	0.54	0.56	0.56	0.41	0.46	0.48	0.45	0.42	0.43	0.44
First-stage statistic	5.73	1.65	80.93	46.82	15.01	5.62	50.32	51.29	13.63	55.27	59.29
Overidentification p-value				0.80				0.00	0.00	0.52	0.00
Dist to 2010 centers	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
History	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: 1300 observations for each regression. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. History variables are dummy variables for municipalities (1) that were Roman settlements (based on DARMC maps), (2) that were major towns between the 10th and the 15th centuries (based on DARMC maps), (3) that were major towns between the 16th and the 19th centuries (based on Bairoch, 1988), (4) with a monastery built between the 12th and 16th centuries (based on DARMC maps), and (5) that hosted important fairs between the 10th and the 16th centuries (based on DARMC maps). Robust standard errors are in parentheses. ^{a}, ^{b}, and ^{c} indicates significant at 1, 5, and 10 percent level, respectively.

Panel B shows results for all non-RER railroads, that is, for the distance to the nearest commuter train, métro or tramway station. Once again, we find a significant effect for each historical network (Columns 5 to 7) and for the joint estimate (Column 8), but the latter does not pass the overidentification test. According to the first-stage F-statistics and the overidentification p-values, the distance to the nearest 1870 railroad and the distance to the nearest Roman road is our preferred pair combination (Column 10).

Finally, in Panel C we explore the instruments for the highways (distance to the nearest highway ramp) (Columns 1 to 4) and for all non-RER transportation (distance to the nearest railroad station or highway ramp) (Columns 5 to 11). Similar to previous panels, our preferred instruments are the distances to the nearest 1870 railroad and to the nearest Roman road (Columns 4 and 10).

3.3 Transportation infrastructure and the location of employment and population in 2010

As we did for the case of the CBD and the subcenters, we turn our attention to analyze the spatial influence of transportation on the intrametropolitan distribution of employment and population in Paris metropolitan area in 2010. Since our focus is on the RER, we regress the log of the 2010 employment (alternatively, population) density on the distance to the nearest RER station in 2010, while controlling for the distance to other types of transportation infrastructures. As before, the distance to nearest 2010 employment center, geographical and historical characteristics are also included in the regression:

$$\begin{aligned}
2010 \ln(\text{Density}) = \delta_0 &+ \delta_1 \times 2010 \text{ distance to RER station} \\
&+ \delta_2 \times 2010 \text{ distance to non-RER station or ramp} \\
&+ \delta_3 \times \text{distance to the nearest 2010 employment center} \\
&+ \sum_i (\delta_{4,i} \times \text{geography}_i) + \sum_i (\delta_{5,i} \times \text{history}_i)
\end{aligned} \tag{5}$$

As in Eq. (3), the coefficients δ_1 and δ_2 are density gradients and capture the extent to which density increases with proximity to the nearest RER station and to the nearest non-RER station or highway ramp, respectively. In order to correct the endogeneity biases discussed above, we estimate this equation using a two-stage least square (TSLS) procedure, where Roman roads and 1870 railroads are used as instruments for the RER and the non-RER variables (following first-stage results in Table 5).

Table 6 reports results for Equation (3) in terms of employment density (Columns 1 to 5) and population density (Columns 6 to 10). In both cases, we find that transportation infrastructures do influence the location of employment and population: the estimated density gradients are always negative and significant. In particular, our results show that getting closer to an RER station by one kilometer increases employment and population densities by around 5-6% and 4-5%, respectively. Results also show higher (but less significant) effects for non-RER transportation: each additional kilometer closer to a non-RER station or ramp increases employment and population densities by

7-8% and 6-7%, respectively. Since these non-RER coefficients are of the same order of magnitude, and do not change the RER coefficient much, in the rest of the paper we present our results controlling only for the group of non-RER infrastructures (including highways ramps), which correspond to the specification used in Columns 5 and 10.

Table 6: Urban spatial structure and proximity to RER stations and other transportation, TSLS

Dependent variable:	2010 ln(Employment density)					2010 ln(Population density)				
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
2010 Distance to the nearest RER station	-0.063^a	-0.063^a	-0.063^a	-0.052^a	-0.055^a	-0.050^a	-0.050^a	-0.050^a	-0.041^a	-0.043^a
	(0.007)	(0.007)	(0.007)	(0.009)	(0.008)	(0.005)	(0.006)	(0.005)	(0.007)	(0.006)
2010 Distance to the nearest commuter train		-0.074^c					-0.061^b			
		(0.039)					(0.030)			
2010 Distance to the nearest non-RER station			-0.079^c					-0.066^b		
			(0.042)					(0.032)		
2010 Distance to the nearest highway ramp				-0.072^c					-0.060^b	
				(0.038)					(0.030)	
2010 Distance to the nearest non-RER stat/ramp					-0.084^c					-0.069^b
					(0.044)					(0.034)
Distance to the nearest 2010 center	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
History	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
First-stage statistic	231.26	38.46	34.00	23.68	54.16	231.26	38.46	34.00	23.68	54.16
Instrument:										
Distance to the nearest 1870 railroad line	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Distance to the nearest Roman road	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: 1300 observations for each regression. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. History variables are dummy variables for municipalities (1) that were Roman settlements (based on DARMC maps), (2) that were major towns between the 10th and the 15th centuries (based on DARMC maps), (3) that were major towns between the 16th and the 19th centuries (based on Bairoch, 1988), (4) with a monastery built between the 12th and 16th centuries (based on DARMC maps), and (5) that hosted important fairs between the 10th and the 16th centuries (based on DARMC maps). Robust standard errors are in parentheses. ^{a}, ^{b}, and ^{c} indicates significant at 1, 5, and 10 percent level, respectively.

4 The effect of the RER on local growth in Paris metropolitan area

Recent literature has analyzed the effects of transportation infrastructures on several city outcomes including urban growth (Duranton and Turner, 2012), population suburbanization (Baum-Snow, 2007; Garcia-López, 2012; Garcia-López et al., 2015a), employment decentralization (Baum-Snow and Kahn, 2000) and urban segregation (Glaeser et al., 2008).

We investigate the effects of transportation (improvements) on local growth in jobs and in the number of inhabitants in the Paris metropolitan area. Our paper brings several new insights to this literature. First, it focuses on the intrametropolitan level, that is, on the municipalities that make up the Paris Metropolitan Area, while most previous studies are at the city-metropolitan level. Second, we study the effects on both employment and population growth, while previous studies focus on just one or the other. Finally, although our main interest is the effects of the RER, we also control for other modes of transportation, while most previous studies consider just one type of infrastructure.

In the following subsections, we first study the effects of RER on local growth for all 1300 municipalities that make up Paris metropolitan area (named *average metropolitan effects*). Then, we group the municipalities according to their proximity to an RER station to explore whether the RER effects are heterogeneous in space (named *effects by distances*). Finally, we analyze the temporal scope of the RER effects by considering different time periods (named *effects by periods*).

Since firm and residential location responses to transportation improvements might take years, our empirical strategy is based on the 'traditional' growth equation, in which a 'growth' dependent variable (between years *t* and *t-1*) is regressed on a set of explanatory variables with their values in the initial year *t-1*.

4.1 Average metropolitan effects

We begin by analyzing the impact of RER and other transportation on local (municipal) growth, both in terms of employment and population. We focus on the 1968–2010 period to estimate the following regression:

$$\begin{aligned}
\text{1968–2010 } \Delta\ln(\text{Density}) = \mu_0 &+ \mu_1 \times \text{2010 distance to RER station} \\
&+ \mu_2 \times \text{1968 distance to non-RER stations and ramps} \\
&+ \mu_3 \times \text{1968 ln(densities)} \\
&+ \mu_4 \times \text{distance to the nearest 1968 employment center} \\
&+ \sum_i (\mu_{5,i} \times \text{geography}_i) + \sum_i (\mu_{6,i} \times \text{history}_i) \\
&+ \sum_i (\mu_{7,i} \times \text{1968 socioeconomy}_i)
\end{aligned} \tag{6}$$

It is important to point out that, since there were no RER stations in 1968, our main explanatory variable is the distance to the nearest RER station in 2010. On the other hand, since there were other railroads and highways in the initial year, we add the distance to the nearest non-RER transportation (station or ramp) in 1968. As previously, we also control for characteristics related to the initial urban spatial structure of the Paris metropolitan area, *i.e.*, the 1968 employment and population densities, the distance to the nearest 1968 employment center, and the geography and history discussed above. We additionally control for the 1962 population size, and 1968 municipal socioeconomic characteristics: unemployment rate; share of employment in manufacturing, in construction, and in services, used as proxies for the economic specialization; share of executives and professional workers as proxy for the level of income; and share of population with university degree as a proxy for the level of human capital. Here again, we run two-stage least square regressions to correct for endogeneity, using distance to the nearest 1870 railroad and distance to the nearest Roman road as instruments.

Table 7 reports our main TSLS results for employment (Columns 1 to 3) and for population (Columns 4 to 6). In Columns 1 and 4, we only include the 2010 distance to RER station and the other control variables. In Columns 2 and 5, we only include the 1968 distance to non-RER transportation. In Columns 3 and 6, we include both transportation variables. We find negative and significant effects for RER and non-RER transportation, revealing that employment and population growth increase the closer a municipality is to a railroad station (RER and non-RER) or a highway ramp.

More precisely, each additional kilometer closer to the nearest RER station increases employment growth by 2% and population growth by 1%. Yet, the effects are higher for the 1968 non-RER transportation, increasing employment and population growth by 9% and 6%, respectively.[4] Finally, it is important to notice that the coefficients for both distances are not statistically different when they are individually, as opposed to jointly, estimated (Columns 1 and 2 vs. 3 for employment, Columns 4 and 5 vs. 6 for population). We take advantage of this feature in our last empirical analysis.

Table 7: The effect of RER on municipality growth, TSLS: Average metropolitan effects

Dependent variable:	1968–2010 Δln(Employment density)			1968–2010 Δln(Population density)		
	[1]	[2]	[3]	[4]	[5]	[6]
2010 Distance to RER station	-0.018^a		-0.023^a	-0.011^a		-0.014^a
	(0.005)		(0.005)	(0.003)		(0.004)
1968 Distance to non-RER stat/ramp		-0.068^a	-0.089^a		-0.048^a	-0.061^a
		(0.023)	(0.022)		(0.015)	(0.015)
1968 ln(Employment density)	-0.543^a	-0.574^a	-0.543^a	-0.011	-0.030	-0.011
	(0.078)	(0.080)	(0.076)	(0.058)	(0.058)	(0.057)
1968 ln(Population density)	0.629^a	0.653^a	0.463^a	0.038	0.044	-0.075
	(0.089)	(0.075)	(0.088)	(0.063)	(0.050)	(0.061)
Distance to the nearest 1968 center	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y
History	Y	Y	Y	Y	Y	Y
1968 Socioeconomy	Y	Y	Y	Y	Y	Y
First-stage statistic	164.05	61.72	30.22	164.05	61.72	30.22
Instrument:						
Distance to the nearest 1870 railroad line	✓	✓	✓	✓	✓	✓
Distance to the nearest Roman road	✓	✓	✓	✓	✓	✓

Notes: 1300 observations for each regression. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. History variables are the population level in 1962 and dummy variables for municipalities (1) that were Roman settlements (based on DARMC maps), (2) that were major towns between the 10th and the 15th centuries (based on DARMC maps), (3) that were major towns between the 16th and the 19th centuries (based on Bairoch, 1988), (4) with a monastery built between the 12th and 16th centuries (based on DARMC maps), and (5) that hosted important fairs between the 10th and the 16th centuries (based on DARMC maps). Socioeconomic variables are the 1968 unemployment rate, the 1968 shares of employment in Manufacturing, in Construction, and in Services, the 1968 share of executives and professionals, and the 1968 share of population with university degree. Robust standard errors are in parentheses. ^{a}, ^{b}, and ^{c} indicates significant at 1, 5, and 10 percent level, respectively.

A closer look at the estimates for initial employment and population densities also provides interesting insights. For the case of employment (Columns 1 to 3), the positive and significant coefficients for the 1968 log of population density and the negative and significant coefficients for the 1968 log of employment density reveal that employment growth is higher in (initial) (densely)

[4]We also conducted the estimations with the 2010 distance to the nearest non-RER transportation in specifications in Columns 2, 3, 5 and 6. These alternatives specifications produce estimates of the coefficient of 2010 non-RER distance that are statistically indistinguishable from the coefficient of the 1968 distance reported in Table 7.

populated areas and lower in municipalities with (initial) high employment density levels, respectively. In other words, employment only follows population. On the other other hand, we do not find any significant effect of initial densities on population growth (Columns 4 to 6).

4.2 *Spatial heterogeneity: Proximity matters!*

Admittedly, the results discussed above show very limited growth effects. This is not surprising since, as we have already noticed, these effects are *average* effects estimated for the 1,300 municipalities that make up the Paris metropolitan area. In this subsection, we explore whether these effects are stable or rather heterogeneous and variable across space.

Since our main explanatory variables are location variables computed in terms of proximity (distances), we analyze the 'spatial' heterogeneity using a distance threshold. According to the 2008 Transportation Survey[5], an average French resident commutes 10.7 km to go to work, the corresponding figures for Parisians and for residents of the outer suburbs (*grande couronne*) being 6.6 and 14.6 km, respectively. With slightly different definitions of Paris metropolitan area, Aguilera and Mignot (2004) and Aguilera (2005) compute average work-home distances of 13.5 and 11.3 km, respectively. Based on the these reported distances, we define our distance threshold at 13 km.

Table 8: The effect of RER on municipality growth, TSLS: Effects by distances

Dependent variable:	1968–2010 Δln(Employment density)		1968–2010 Δln(Population density)	
	dist to RER		dist to RER	
	$\leq$ 13 km	$>$ 13 km	$\leq$ 13 km	$>$ 13 km
	[11	[2]	[3]	[4]
2010 Distance to RER station	-0.122^b	0.005	-0.080^c	-0.007
	(0.064)	(0.016)	(0.042)	(0.009)
1968 Distance to non-RER stat/ramp	-0.241^a	-0.039^b	-0.154^a	-0.027^b
	(0.069)	(0.015)	(0.044)	(0.011)
1968 ln(Employment density)	Y	Y	Y	Y
1968 ln(Population density)	Y	Y	Y	Y
Distance to the nearest 1968 center	Y	Y	Y	Y
Geography	Y	Y	Y	Y
History	Y	Y	Y	Y
1968 Socioeconomy	Y	Y	Y	Y
First-stage statistic	14.55	11.75	14.55	11.75
Instrument:				
Distance to the nearest 1870 railroad line	✓	✓	✓	✓
Distance to the nearest Roman road	✓	✓	✓	✓

Notes: 782 and 518 observations for regressions in Columns 1 and 3 and in Columns 2 and 4, respectively. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. History variables are the population level in 1962 and dummy variables for municipalities (1) that were Roman settlements (based on DARMC maps), (2) that were major towns between the 10th and the 15th centuries (based on DARMC maps), (3) that were major towns between the 16th and the 19th centuries (based on Bairoch, 1988), (4) with a monastery built between the 12th and 16th centuries (based on DARMC maps), and (5) that hosted important fairs between the 10th and the 16th centuries (based on DARMC maps). Socioeconomic variables are the 1968 unemployment rate, the 1968 shares of employment in Manufacturing, in Construction, and in Services, the 1968 share of executives and professionals, and the 1968 share of population with university degree. Robust standard errors are in parentheses. ^{a}, ^{b}, and ^{c} indicates significant at 1, 5, and 10 percent level, respectively.

[5]See the INSEE website for more details.

Table 8 shows results of estimating Eq. (6) for two different subsamples of municipalities grouped according to their proximity to an RER station. From the original 1,300 municipalities, our first subsample is made up of 782 municipalities that are located less than 13 km from an RER station (Columns 1 and 3). The other group is based on the 518 municipalities with an RER station beyond 13 km (Columns 2 and 4).

We do find that the effects of RER are heterogeneous in terms of proximity to this infrastructure. While these effects are significant for municipalities located less than 13 km away from an RER station (Columns 1 and 3), they are statistically insignificant for those located beyond 13 km (Columns 2 and 4). Furthermore, compared to the average effects, now we do find *higher* growth effects: each additional kilometer closer to an RER station increases employment growth by 12% and population growth by a 8% in municipalities located less than 13 km away from an RER station.

As for non-RER transportation, we also observe heterogeneity in their results: larger effects for municipalities closer to an RER station (24% for employment and 15% for population), and smaller effects for the most distant municipalities (4% for employment and 3% for population).

In summary, although the results reported in Table 7 show very limited growth effects, these results are *on average*, for the whole metropolitan area. When we split our sample, new results in Table 8 clearly show that growth effects are *higher* and *more local*. In other words, proximity matters!

4.3 Temporal heterogeneity: Effects need time!

We now turn our attention to analyze different time periods. The purpose is twofold. First, to estimate a version of Eq. (6) in which our main explanatory variable, the distance to the nearest RER station, also uses values in the initial year. To consider this 'more traditional' growth equation, we focus on the 1975–2010 period, which witnessed the advent and expansion of the RER network. We therefore test the robustness of our previous results on the impact of the RER.

Second, we also investigate the temporal scope of the RER effects. As mentioned above, employment and population responses to transportation improvements might take years. Since the length of this delay is unclear, we explore it by regressing growth equations for the 1975–1990 and 1990–2010 periods.

Conditional on the *year t-1* employment and population densities, distance to nearest employment center, geography, history and socioeconomic variables in *year t-1*, we regress the (employment and population) growth between *year t-1* and *year t* on the distance to the nearest RER station in *year t-1* (or *year t-2*):

$$\begin{aligned} \textit{year t-1} - \textit{year t}\ \Delta\ln(\text{Density}) = \eta_0 &+ \eta_1 \times \textit{year t-1} \text{ or } \textit{t-2} \text{ distance to RER station} \\ &+ \eta_2 \times \textit{year t-1} \ln(\text{densities}) \\ &+ \eta_3 \times \text{distance to the nearest 1968 employment center} \\ &+ \sum_i (\eta_{4,i} \times \text{geography}_i) + \sum_i (\eta_{5,i} \times \text{history}_i) \\ &+ \sum_i (\eta_{6,i} \times \textit{year t-1} \text{ socioeconomy}_i) \end{aligned} \tag{7}$$

Compared with Eq. (6), this new Eq. (7) omits the distance to other transportation infrastructures since, as mentioned above, it does not significantly affect the coefficients of interest. This empirical strategy also allows us to overcome a problem with one of our instruments, the distance to the nearest Roman road, which is not relevant in some periods. As a result, Eq. (7) is estimated by TSLS using the distance to the nearest 1870 railroad as the unique instrument.

Table 9 reports TSLS results for Eq. (7) for employment (Columns 1 to 4) and population (Columns 5 to 8). While Columns 1 and 5 show results for the shortened 1975–2010 period, Columns 2 and 5 and Columns 3-4 and 7-8 for the subperiods 1975–1990 and 1990–2010, respectively. Finally, most specifications follow the traditional growth equation with the *year t-1* lagged RER distance (Columns 1 to 3 and 5 to 7), in Columns 4 and 9 we use the *year t-2* RER distance (i.e., 1975).

Table 9: The effect of RER on municipality growth, TSLS: Effects by periods

Dependent variable:	Δln(Employment density)				Δln(Population density)			
Period	1975–2010	1975–1990	1990–2010		1975–2010	1975–1990	1990–2010	
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
1975 Dist to RER station	-0.027[a]	-0.006		-0.022[a]	-0.018[a]	-0.014[a]		-0.005[c]
	(0.008)	(0.007)		(0.008)	(0.004)	(0.004)		(0.003)
1990 Dist to RER station			-0.012[a]				-0.003[c]	
			(0.004)				(0.001)	
1975 or 1990 ln(Employment density)	Y	Y	Y	Y	Y	Y	Y	Y
1975 or 1990 ln(Population density)	Y	Y	Y	Y	Y	Y	Y	Y
Dist to 1968 center	Y	Y	Y	Y	Y	Y	Y	Y
Geography	Y	Y	Y	Y	Y	Y	Y	Y
History	Y	Y	Y	Y	Y	Y	Y	Y
1975 or 1990 Socioeconomy	Y	Y	Y	Y	Y	Y	Y	Y
First-stage statistic	50.43	50.43	76.19	27.07	50.43	50.43	76.19	27.07
Instrument:								
Dist to 1870 railroads	✓	✓	✓	✓	✓	✓	✓	✓

Notes: 1300 observations for each regression. Geography variables are land area, altitude, index of terrain ruggedness, and elevation range. History variables are population levels in 1962 and 1968 (all columns) and 1975 and 1982 (columns 3 and 6); employment levels in 1968 (all columns) and 1975 and 1982 (columns 3 and 6); and dummy variables for municipalities (1) that were Roman settlements (based on DARMC maps), (2) that were major towns between the 10th and the 15th centuries (based on DARMC maps), (3) that were major towns between the 16th and the 19th centuries (based on Bairoch, 1988), (4) with a monastery built between the 12th and 16th centuries (based on DARMC maps), and (5) that hosted important fairs between the 10th and the 16th centuries (based on DARMC maps). Socioeconomic variables are the unemployment rate, the shares of employment in Manufacturing, in Construction, and in Services, the share of executives and professionals, and the share of population with university degree with their values in 1975 (columns 1–2 and 4–6) or in 1990 (columns 3 and 6). Robust standard errors are in parentheses. [a], [b], and [c] indicates significant at 1, 5, and 10 percent level, respectively.

The estimates for the employment and population growth equations over the whole 1975–1990 period (Columns 1 and 5) are consistent with those obtained previously in Table 7: one kilometer closer to an RER station in 1975 increases employment growth by 2.7% and population growth by 1.8% between 1975 and 2010.

The analysis by subperiods shows different time responses to RER improvements for employment and population. For the case of employment, we do not find a significant RER effect on the 1975–1990 period (Column 2). In contrast, the RER effect appears in the 1990–2010 period when we use the 1990 distance in Column 3 (which includes both the 1975 and 1975–1990 RER networks) and it is clearer when we use the 1975 distance in Column 4. Therefore, it seems that the RER effect emerges after a certain time lag. As for population, the RER effect turns out to be much more rapid, increasing population growth by 1.4% each additional kilometer closer to an RER station in the 1975-1990 period (Column 6). However, at the same time, the RER effect tends to decrease over time: increasing population growth only by 0.3% (Column 7) and 0.5% (Column 8) in the 1990–2010 period.

To sum up, these new results by periods clearly show that, first, our previous results based on the 1968–2010 period are robust, and, second, that RER effects are heteregenous in time and differ between firms and residences: while there is a lagged response by firms which increases with time, the response by residences is more rapid, but decreases with time.

5 Conclusions

In this paper we have investigated the effect of the RER expansion, while controlling for all the other transportation modes, on employment and population growth in the Paris metropolitan area municipalities between 1968 and 2010. Because of the potential endogeneity problem of transportation provision, we first study whether the construction and location of railroads and highways are influenced by historical roads. According to the first-stage results and our own considerations, the two historical networks considered in this study are the 1870 railroad network and the Roman roads. This first stage analysis allows us to conclude that historical railroads and roads account for the present-day infrastructure. The main results indicate that the RER network together with the other transportation networks have a positive and significant effect on the location of employment and population. In a dynamic analysis, we show that with each additional kilometer a municipality is located closer to an RER station employment increases by 2% and the population increases by 1%. Heterogeneous analyses in terms of space and time show that these effects are higher when a municipality is located less than 13 km from an RER station and when employment and population growth increase by 12% and 8% per km, respectively. Regarding the temporal scope we show that for the first part of the period there were no effects of the RER expansion on employment growth. On the other hand, the RER expansion effect on the population growth was much more intense in the first period. Also our results indicate that this impact decreases with time.

This paper's contribution is of relevance because it provides much-needed evidence from an analysis conducted at the intrametropolitan level in one of the largest metropolitan areas in Europe. Furthermore, our results for the Paris metropolitan area complement those obtained by Mayer and Trévien (2015) using a different empirical strategy with a restricted sample of municipalities from the Paris metropolitan area. It is also important to note that some of our suburban and intrametropolitan results verify the theoretical predictions we discuss. First, we confirm that railroad and highway effects are heterogeneous in CBD distance. Second, we also provide evidence that the suburbanized population and employment are not evenly distributed across the suburbs; on the contrary, the population spreads out along the highways in the first stage of infrastructure development, while in this same stage, employment follows population.

A better understanding of the relationship between improvements in transport infrastructure, on the one hand, and city structure and city growth, on the other, is important, in general, for transport planners, urban planners, and policy makers and, in particular, it is crucial for making correct transport forecasts. Here, we have examined the impact of the initial stages in the development of the RER rail network on growth. Our results show that railroad investment has a major impact in these early years on population growth but not on employment growth. Further research is, however, required to determine whether this effect is weakened as the network becomes denser.

Finally, although the paper has studied the effects of railroads (mainly the expansion of the RER), together with the impacts of the expansion of other network infrastructures, on changes in the urban spatial structure of the Paris Metropolitan Area over the last 40 years, we have not considered the effects on changes in employment by industrial sector and how the location patterns of these industries may differ according to the distribution of the employment subcenters. Although such an analysis would be interesting in order to determine the dynamics of the economic structure in the Paris metropolitan area, this task goes far beyond the objective of the current paper and we leave this task for future research.

References

Aguilera, A. (2005). Growth in commuting distances in French polycentric metropolitan areas: Paris, Lyon and Marseille. *Urban Studies*, 42(9):1537–1547.

Aguilera, A. and Mignot, D. (2004). Urban sprawl, polycentrism and commuting. A comparison of seven French urban areas. *Urban Public Economics Review*, 1:93–114.

Bairoch, P. (1988). *Cities and Economic Development: From the Dawn of History to the Present*. University of Chicago Press.

Banerjee, A., Duflo, E., and Qian, N. (2012). On the road: Access to transportation infrastructure and economic growth in China. Working Paper 17897, National Bureau of Economic Research.

Baum-Snow, N. (2007). Did highways cause suburbanization? *The Quarterly Journal of Economics*, 122(2):775–805.

Baum-Snow, N. (2010). Changes in transportation infrastructure and commuting patterns in US metropolitan areas, 1960-2000. *American Economic Review*, 100(2):378–82.

Baum-Snow, N. and Kahn, M. E. (2000). The effects of new public projects to expand urban rail transit. *Journal of Public Economics*, 77(2):241–263.

Carlino, G. A. and Saiz, A. (2008). City beautiful. Working Paper 08–22, Federal Reserve Bank of Philadelphia.

Combes, P.-P., Duranton, G., Gobillon, L., Puga, D., and Roux, S. (2012). The productivity advantages of large cities: Distinguishing agglomeration from firm selection. *Econometrica*, 80(6):2543–2594.

Donaldson, D. (2015). Railroads of the Raj: Estimating the impact of transporation infrastructure. *American Economic Review*, forthcoming.

Duranton, G. and Turner, M. A. (2011). The fundamental law of road congestion: Evidence from US cities. *American Economic Review*, 101(6):2616–52.

Duranton, G. and Turner, M. A. (2012). Urban growth and transportation. *The Review of Economic Studies*, 79(4):1407–1440.

Faber, B. (2014). Trade integration, market size, and industrialization: Evidence from China's National Trunk Highway System. *Review of Economic Studies*, 81:1046–1070.

Garcia-López, M.-A. (2010). Population suburbanization in Barcelona, 1991-2005: Is its spatial structure changing? *Journal of Housing Economics*, 19(2):119–132.

Garcia-López, M.-A., Holl, A., and Viladecans-Marsal, E. (2015a). Suburbanization and highways in Spain when the Romans and the Bourbons still shape its cities. *Journal of Urban Economics*, 85(0):52 – 67.

Garcia-López, M.-A., Pasidis, I., and Viladecans-Marsal, E. (2015b). Express delivery to the suburbs? Transportation effects in heterogeneous European cities. Mimeo.

Garcia-López, M.-A. (2012). Urban spatial structure, suburbanization and transportation in Barcelona. *Journal of Urban Economics*, 72(2–3):176–190.

Gilli, F. (2009). Sprawl or reagglomeration? The dynamics of employment deconcentration and industrial transformation in Greater Paris. *Urban Studies*, 46(7):1385–1420.

Glaeser, E. L. and Gottlieb, J. D. (2009). The wealth of cities: Agglomeration economies and spatial equilibrium in the United States. *Journal of Economic Literature*, 47(4):983–1028.

Glaeser, E. L., Kahn, M. E., and Rappaport, J. (2008). Why do the poor live in cities? The role of public transportation. *Journal of Urban Economics*, 63(1):1–24.

Glaeser, E. L., Kolko, J., and Saiz, A. (2001). Consumer city. *Journal of Economic Geography*, 1(1):27–50.

Guillain, R., Le Gallo, J., and Boiteux-Orain, C. (2006). Changes in spatial and sectoral patterns of employment in Ile-de-France, 1978-97. *Urban Studies*, 43(11):2075–2098.

Hsu, W.-T. and Zhang, H. (2014). The fundamental law of highway congestion revisited: Evidence from national expressways in Japan. *Journal of Urban Economics*, 81(C):65–76.

Jiwattanakulpaisarn, P., Noland, R., Graham, D., and Polak, J. (2009). Highway infrastructure investment and county employment growth: A dynamic panel regression analysis. *Journal of Regional Science*, 49:263–286.

Martí-Henneberg, J. (2013). European integration and national models for railway networks (1840–2010). *Journal of Transport Geography*, 26(0):126–138.

Mayer, T. and Trévien, C. (2015). The impacts of urban public transportation: Evidence from the Paris metropolitan area. Working Paper G2015/03, INSEE.

McDonald, J. F. and Prather, P. J. (1994). Suburban employment centers: The case of Chicago. *Urban Studies*, 31(2):201–218.

McMillen, D. P. (2001). Nonparametric employment subcenter identification. *Journal of Urban Economics*, 50(3):448 – 473.

McMillen, D. P. (2003). Identifying sub-centres using contiguity matrices. *Urban Studies*, 40(1):57–69.

Michaels, G. (2008). The effect of trade on the demand for skill: Evidence from the interstate highway system. *The Review of Economics and Statistics*, 90(4):683–701.

Moretti, E. (2004). Workers' education, spillovers, and productivity: Evidence from plant-level production functions. *American Economic Review*, 94(3):656–690.

Rosenthal, S. and Strange, W. (2008). The attenuation of human capital spillovers. *Journal of Urban Economics*, 64(2):373–389.

Stock, J. H. and Yogo, M. (2005). Testing for weak instruments in linear IV regression. In Andrews, D. W. and Stock, J. H., editors, *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, pages 80–108. Cambridge: Cambridge University Press.

2011

2011/1, Oppedisano, V; Turati, G.: "What are the causes of educational inequalities and of their evolution over time in Europe? Evidence from PISA"
2011/2, Dahlberg, M; Edmark, K; Lundqvist, H.: "Ethnic diversity and preferences for redistribution"
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